ENERGY CONSUMPTION AND ECONOMIC GROWTH:
A PANEL ANALYSIS

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Statement of Originality

The work described in this Final Year Project, entitled
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is to the best of the author's knowledge that of the author except
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ABSTRACT

ENERGY CONSUMPTION AND ECONOMIC GROWTH: A PANEL ANALYSIS

By

Chye Xiao Hui

The main purpose of this study is to investigate the relationship between energy consumption and economic growth between 17 Asian countries, using annual time series and cross sectional data covering the period from 1980 to 2006. Panel tests are applied in this study. The conclusions are: first, energy consumption and Gross Domestic Product (GDP) are stationary in the first difference. Second, results show a cointegration between these two variables, which indicate that GDP and economic consumption are moving together in a long run relationship. Third, energy consumption has a positive effect on GDP. Fourth, energy consumption does Granger cause to GDP in the short run and there exists a long run causal linkage running from GDP to energy consumption. This indicates that energy is a force for economic growth in the short period of time but development of economies is less dependent on energy in the long term. Some policies have been recommended in this study that could be carried out by the government of these Asian countries as to support the economic development for future.

ABSTRAK

PENGGUNAAN TENAGA DAN PERTUMBUHAN EKONOMI: ANALISA PANEL

Oleh

Chye Xiao Hui

Tujuan utama kajian ini dijalankan adalah untuk menyiasat hubungan antara penggunaan tenaga dan pertumbuhan ekonomi dalam 17 negara Asian, dengan menggunakan data tahunan siri masa dan keratan lintas meliputi jangka masa dari tahun 1980 ke 2006. Ujian-ujian panel telah diaplikasikan dalam kajian ini. Kesimpulan adalah: pertama, penggunaan tenaga dan Keluaran Dalam Negeri Kasar (KDNK) adalah pegun dalam pembezaan pertama. Kedua, keputusan menunjukkan kewujudan satu kointegrasi di antara dua pembolehubah ini, yang mana menandakan bahawa KDNK dan penggunaan tenaga adalah bergerak dengan sejalar pada jangka masa panjang. Ketiga, penggunaan tenaga mempunyai kesan positif terhadap KDNK. Keempat, penggunaan tenaga mempengaruhi KDNK dalam jangka pendek dan wujudnya pengaruh rangkaian jangka panjang bergerak dari KDNK ke penggunaan tenaga. Ini menandakan bahawa tenaga merupakan satu daya untuk pertumbuhan ekonomi dalam jangka masa pendek tetapi pembangunan ekonomi adalah kurang bergantung kepada tenaga dalam jangka panjang. Beberapa polisi telah dicadangkan dalam kajian ini yang boleh dilaksanakan oleh kerajaan dalam negara-negara Asian bagi menggalakkan pembangunan ekonomi untuk masa depan.

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CHAPTER ONE

INTRODUCTION

1.0 Overview of the Energy Consumption in Asia

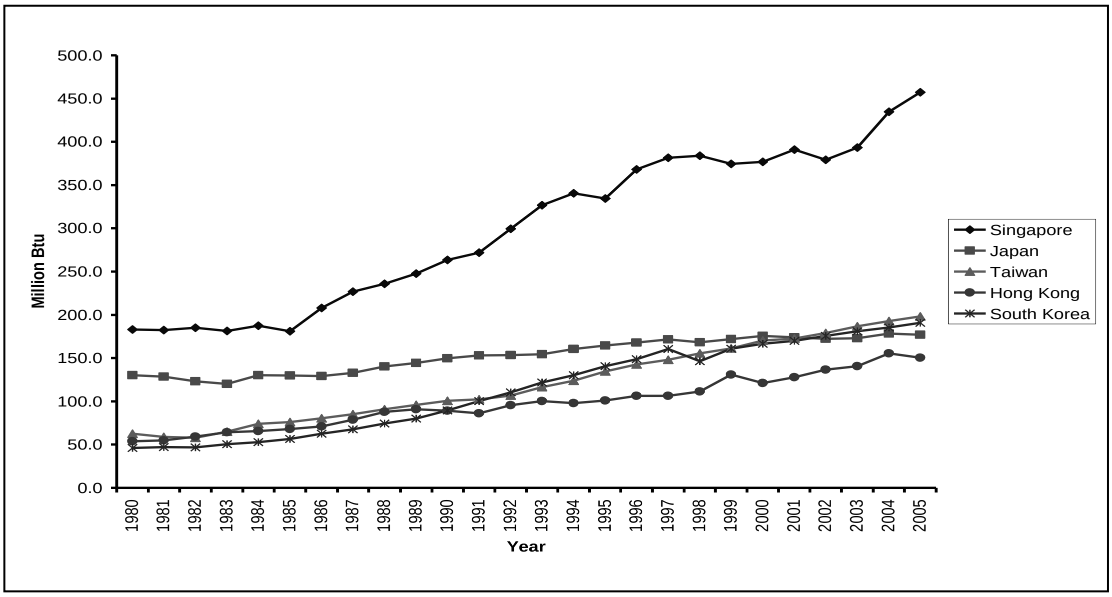
Energy is an important source which contributes to the economic growth of a country or a region. It is also essential in human development and in the well-being of society. This is because energy is an input in many production and consumption activities. Fossil fuels are being burned by factories and electric power plants, motor vehicles, and households. Without heat and electricity from fuel combustion, economic activity would be limited and restrained. According to Macmillan (2005), energy power has an ability to multiply the work of labors exponentially. Industrial economy that use engine could lower the production cost and increase the output level. Consequently, energy availability and consumption play a vital role in the process of economic development.

The ratio of energy consumption to economic activity is referred to the energy intensity of an economy. Energy intensity also means the amount of energy needed per unit of Gross Domestic Product (GDP). Energy intensity may be determined by the aggregation of transportation and industrial sectors in a country's economy. When a nation move into a more industrialized country, the energy intensity will rise significantly as the demand of economy production required greater amount of energy per unit of output (Macmillan, 2005).

Total energy consumption is the total amount of primary energy consumed from all sources in the year specified. Primary energy includes uses from transportation, friction, heat loss, and other. The sources consist of petroleum, coal, crude oil, natural gas, nuclear, solar, hydro, peat, natural gas liquids (NGLs), geothermal, combustible renewable and wastes, and heat from heat pumps (EarthTrends, 2003).

In Asian countries, energy consumption has grown strongly and steadily in past few decades. This is most likely due to the population increment and industrial expansion, particularly in China, Japan, Korea, and Malaysia, where the level of energy consumption in those countries are high. The Philippines and Singapore have relatively low energy consumption level. China and Japan have higher energy consumption levels which account for 73.8 percent of energy consumption in East Asia (Sakuramoto *et al.*, 2003).

Figure 1: Per Capita Energy Consumption in Asian Countries, 1980-2005



Source: International Energy Annual 2005, Energy Information Administration

Figure 1 shows that energy consumption in Asian countries from 1980 to 2005. Japan and the “Four Tigers”: South Korea, Taiwan, Singapore, and Hong Kong have per capita energy consumption levels closer to the Europe and the United States (Manning, 2004). These countries are more developed in Asian economies. Singapore has the highest levels of per capita energy consumption among the countries. South Korea tripled its per capita energy consumption from 1980 to 1995. This is reflecting rapid structural change in the South Korean economy, which focused on rapid expansion in steel, shipbuilding, petrochemical, auto and electronics industries.

Asia has the fastest rate of increasing energy consumption in the world. This is caused by its great population and the anticipated rapid economic growth of the Newly Industrializing Economies (NIES) and developing countries. Macmillan (2005) affirmed that during the two decades starting in the late 1970s, China had moved away from a totally state-controlled economy to a partially market-driven system. In this period, China experienced one of the highest growth rates in the world.

According to the data in the International Energy Outlook 2008 from the American Energy Information Administration (EIA), Asia’s total primary energy consumption in 1990 was 47.4 quadrillion British Thermal Units (BTU), 101.0 and 109.9 quadrillion BTU in 2004 and 2005 respectively. It is expected to increase to 137.1 quadrillion BTU in 2010, 164.2 quadrillion BTU in 2015, 189.4 quadrillion BTU in 2020, 215.3 quadrillion BTU in 2025, and 240.8 quadrillion BTU in 2030.

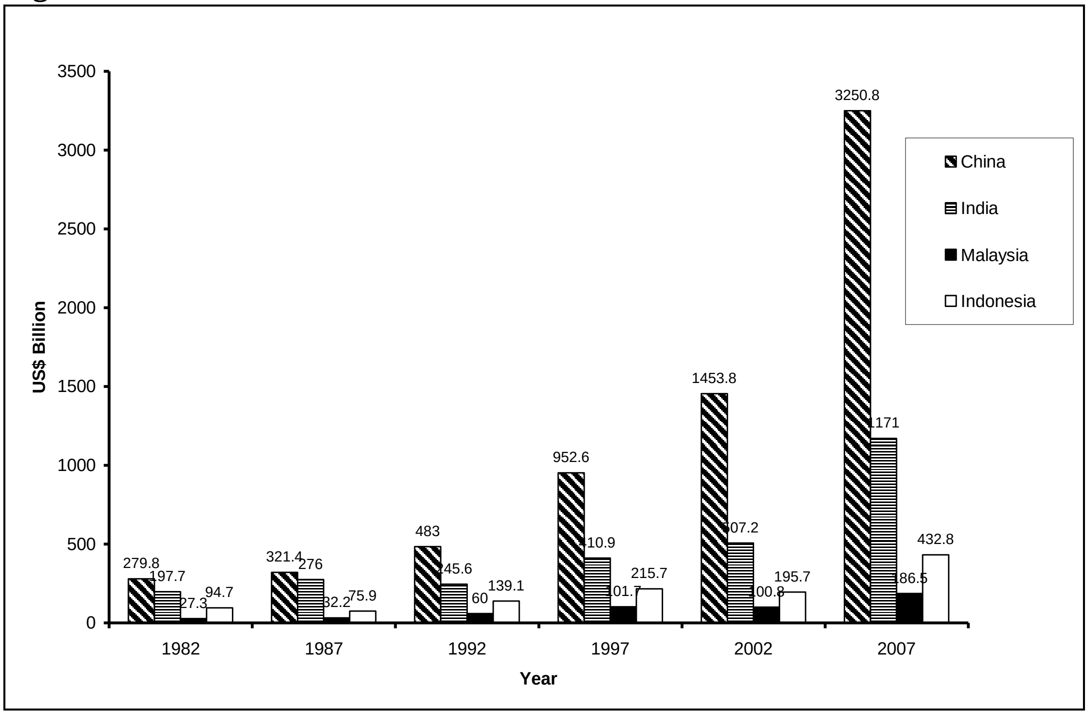
The average annual percent change from 2005 to 2030 in Asia is 3.2 percent, which is higher than other region such as the Middle East countries (1.9 percent), Central and South America (2.0 percent), and Africa (2.0 percent) (EIA, 2008).

Economic growth is among the most important factors to be considered in the Asian energy consumption. Economic growth means the ability of a country to produce more goods and services from one year to another. When the total output from new resources or existing resources are increasing, the country is facing an economic growth (Gale, 2005). Economic growth can be evaluated in term of GDP.

In short term, consumers make spending decisions based on current financial condition such as interest rate and the price of goods and services to be purchased. In the long term, the ability to produce goods and services determines the growth potential for the economy of a nation. The growth potential is influenced by population growth, labor force participation rates, productivity growth, and capital accumulation. In addition, progress in building human and physical capital infrastructures and ensuring political stability also play essential roles in determining the long-term growth potential of a country.

Data in the International Energy Outlook 2008 stated that the average annual growth in GDP of China and India in 2007 was 10.5 percent and 8.5 percent respectively. Meanwhile, the other Asian countries had the GDP of 5.7 percent in 2007 (EIA, 2008).

Figure 2: Growth Rate of Asian Countries GDP, 1982-2007



Source: World Development Indicators 2008, World Bank

Figure 2 plot the GDP in Asian countries, such as China, India, Malaysia, and Indonesia. As observed in Figure 1, China's economy has grown rapidly over the recent years. China is expected to continue playing a major role on both the supply and demand sides of the global economy. The country's economic growth is expected to be the highest in the world. India, another Asian country with a rapid emerging economy also has the positive prospects to continue to grow in the global market. Malaysian and Indonesian economy also increased over the years although their growth rates are lower than China and India.

Economic growth and energy demand are linked but the strength is varied among countries (EIA, 2008). The stage of economic development and the living standard of individuals in a nation are strong influences in the connection between economic growth and energy demand. In advanced economies countries, the citizens have high living standards and relatively high levels of energy use per capita. They enjoy modern appliances and personal transportation equipments.

The oil crises in 1970s had impact on the development of the fuel supply industry. This created opportunity for the growth of other energy resources such as electricity (Manning, 2004). Electricity consumption is expected to have a stronger long-term growth in the developing countries of Asia. Electricity demand and investment in the electric power sector infrastructure is rising due to the movement towards privatization in many parts of the Asian region (EIA, 2000).

1.1 Problem Statement

Pattern of energy consumption in each country are affected by the energy prices. The energy crisis in 1970s and high level of energy prices had negatively influences the economic activities in Asian countries. The serious problems of fuel hike and increasing energy use have brought focus of the Asian countries on the role of energy in economic performance. Moreover, the growing concerns over energy scarcity and environmental costs of energy have attracted interest of the government in Asian countries. Ang (1985) declared that a variety of energy strategies are implemented to promote the rational and efficient use of energy.

Asia, a long recognized major region for production and export of oil, has become one of the world's fastest growing regional consumers of oil. In most of the countries in Asia, energy and energy based inputs play a major role in the production processes (Reddy, 1998). Some countries are non-oil producing countries which energy needs are met by large quantities of imports. Thus, to meet its growing needs of energy, those countries face both energy constraints from supply side and demand management policies (Aqeel, 2001).

Therefore, the causal relationship between energy and economy has undergone investigation. Whether energy consumption leads to economic growth or economic growth stimulates energy consumption have been examined in a number of studies. The causality in either direction between energy consumption and economic growth may have a significant impact upon energy saving policies.

If causality runs from economic growth to energy consumption in a country, this indicates economic of the country is less dependent on energy. Energy saving policies may have no adverse effect on economic growth. However, if causality runs in the reverse direction, this suggests an energy-dependent economy in which a shortage of energy may adversely affect income (Narayan and Smyth, 2008). Energy conservation policies have no impact on economic growth when there is no causality in either direction. Economic activities and energy consumption will influence each other when there occurs a bidirectional causality. The economic growth and energy consumption are highly dependent and energy conservation measures may negatively affect economic growth (Asghar, 2008).

Hence, the study to investigate the causality relationship between economic growth and energy consumption is vital so that the energy conservation policies may be pursued without adversely affecting the economy.

1.2 Objectives of the Study

The general objective of this study is to investigate the relationship between energy consumption and economic growth in 17 Asian countries.

The specific objectives of this study include:

a) To test the long run relationship between energy consumption and economic growth in 17 Asian countries.
b) To empirically examine the direction of causality pattern between energy consumption and economic growth in these Asian countries.

1.3 Significant of the Study

Energy is an essential production factor that fuels economic growth and serves human well-being (Mulder and Groot, 2004). Modern society uses more and more energy for industry, services, homes, and transport. Oil has become the most traded commodity and part of economic growth is linked to its price.

Neither oil nor any other fossil fuels, such as coal and natural gas, are unlimited resources. The growing demand and depleting resources force the countries' government to monitor the energy situation and gain a profound knowledge of energy supply and demand include energy dependency, security, and efficiency, as well as environmental concerns.

High costs of energy supplies and concern about the availability of oil have brought the pressure on all countries to reexamine their national energy policies (Ang, 1985). Policy makers in Asian countries are aware of the seriousness of the situation and of the impact on the decision-making process. Improving the energy efficiency of the country is a significant way of moving towards sustainable economic growth. Moreover, the economy of country could achieve higher growth rate and better living standard.

Energy conservation policies and environmental friendly policies for fossil fuels can be adopted once the causal direction is investigated. The governments of Asian countries can encourage the use of renewable energy and investing in technology that makes alternatives cleaner energy sources more feasible.

Besides, this study will enhance the knowledge of relationship between energy consumption and economic growth as well as future energy consumption needs and potential implications for Asian countries. Understanding the relationship among energy use and economic performance in Asian countries is important to propose projects and implement energy conservative policies in the country. It is also useful with regards to environmental protection and economic development in a country.

1.4 Scope of the Study

The remainder of this study is organized as follows. A brief description of empirical literatures that analyze the energy consumption and economic growth is provided in chapter two. In chapter three, there is an explanation on the study's model, methodology and data used in this study. Chapter four presents and discusses the empirical results of various analyses. Finally, conclusions, policy implications and suggestions of future research are provided in chapter five.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

Energy availability and consumption play a crucial role in the process of economic growth (Chima, 2007). The relationship between energy consumption and economic growth is a well-studied research topic in economics. There are a number of studies carried out in the past which examining the empirical relationship between these two variables. However, these studies differ in methodology according to different country, data used, and results. This chapter is pertaining to the papers that examine the relationship between energy consumption and economic growth, the relationship between electricity consumption and economic growth, and the related studies using panel tests.

2.1 Relevant Literature on Energy Consumption and Economic Growth

The pioneering first-generation study of the relationship between energy consumption and economic growth was presented by Kraft and Kraft (1978). Sims (1972) had been utilized for unidirectional causality test on Gross National Product (GNP) and gross energy inputs for the United States (U.S.). Results illustrated that there was a unidirectional causality running from GNP to energy use over 1947-1974. It implied that energy conservation policies might be enforced without affecting GDP growth (Guttormsen, 2004).

Nguyen (1984) applied the corrected estimated energy coefficients to test for the Organization for Economic Cooperation and Development (OECD) countries for the 1958-1973 periods and examined the relationship between energy consumption and economic growth. He found that the energy coefficient is a useful tool to investigate the total energy consumption. When estimating a cross-section of countries at single points in time, the useful energy coefficient of the whole set will fall from high values to one. Compared to the unadjusted coefficient for most industrialized countries have been found to be less than one. Besides, thermal efficiency was used to estimate the fuel efficiency. The concept of thermal efficiency coefficients is based on the heat content of each fuel which makes machines work has to be considered in the Gross Domestic Product (GDP). Results revealed that the output elasticity of useful energy consumption (ε) did fall steadily from high values to values which are still higher that one.

The paper of Nachane *et al.* (1988) which studied on energy and GDP relationship, was the first study that using cointegration methodology, based on annual data over the period of 1950-51 to 1984-85. A long-run linear equilibrium relationship exists between the Per Capital Energy Consumption (PCEC) and Per Capital Gross Domestic Product (PCGDP) for 11 developing countries and five developed countries. The influences of PCGDP on PCEC include the changes in the element of the GDP of a country which accompany by the PCGDP changes in the growth of secondary and tertiary sectors, rise in PCGDP causes the technical changes which affect the energy usage efficiency in manufacturing, and changes in standard of living which influence people to switch from one form of energy consumption to another. All these influences are essentially long-term influences.

Adam and Chen (1996) employed a different approach that they looked into the physical measurement of energy consumption to evaluate the real GDP growth. They investigated the quantitative relationship between the two variables in China, in eight other Asian countries, and in the U.S. Results shown that the elasticity of energy consumption in China is lower than in the U.S. and in other East Asian countries. They believed that the Chinese official statistics overstated the Chinese GDP growth rate. Thus, they did a reassessment of Chinese real GDP growth based on the average GDP electricity of energy consumption in East Asian countries. Results of the reassessment were lower than in the Chinese official statistics. Explanations given by the researchers stated that the China lower energy intensity sectors grown more rapidly than high energy intensive sectors, the efficiency of energy consumption has been improving over time, and the Chinese official statistics has overstated the Chinese GDP growth.

The Granger causality between energy consumption and economic growth for Brazil, Mexico, and Venezuela was investigated by Cheng (1997). Data on GDP, economic consumption, and capital for Mexico from 1949 to 1993, Venezuela from 1952 to 1993, and Brazil from year 1963 to 1993 were utilized. The study found no causality between energy consumption and economic growth for Mexico and Venezuela but capital is negatively and weakly causes energy consumption for the two countries. Thus, they suggested that energy and capital are substitutes of factors of production. In Brazil, energy consumption negatively causes economic growth. It implies that decrease in energy consumption would boosts economic growth in Brazil. This may indicates that energy conservation would not cause an adverse effect on economic growth.

Masih and Masih (1998) were among the first that using the Johansen multivariate cointegration to examine the energy use and economic growth relationships. They found a relationship but no evidence of direction for Thailand and Sri Lanka (Guttormsen, 2004). By using Vector Error-Correction Model (VECM), they had analyzed the direction of Granger causality. Energy consumption was found to play an essential role in determining the other variables in each country. In Sri Lanka, energy consumption played a much more influential role in explaining shock to income than in Thailand, although energy was responsible in explaining more of price shocks in Thailand. Shocks to the system have more sustained effect in Thailand than in Sri Lanka.

According to Reddy (1998), the Pacific island region is heavily dependent on imported petroleum products to meet their local energy demand. Heavy dependence on imported oil products makes the island economic expose to economic shock. He had examined the pattern of energy consumption and growth in Fiji from 1970 to 1987 with the Ordinary Least Square (OLS) estimation. Results revealed that the total energy use in Fiji commercial sector has been expanded. Results also contained a negative structural change effect and conservation effect which would directly cause a fall in energy intensity of transport sector. Moreover, the household energy consumption rate in Fiji has increased significantly. Demographic changes, lack of conservation and inefficiency in energy use have contributed to the growth in energy consumption. Population in Fiji increase lead to the growth in energy consumption in the household sector.

Stern (1998) used the Vector Autoregression (VAR) model with variables which are GDP, energy use, capital, and labor inputs on the U.S. data from 1948-1994 and found evidences that energy was to Granger cause GDP. Results revealed that energy is significant in explaining GDP. There are increasing returns in term of GDP when energy is increase. Moreover, there is cointegration in a relationship include GDP, capital, labor, and energy. In recessions, labor use is below the long-run equilibrium. In economic booms, more labor enters the work-force when labor supply is above the equilibrium. GDP is responds positively to labor oversupply. The results supported by the finding of his previous research in 1993 regarding Granger causality between energy and GDP (Stern, 1998).

Aqeel and Butt (2001) examined the causal relationship between energy consumption and economic growth, and energy consumption and employment in Pakistan from 1955-1956 to 1995-1996 by applying Hsiao's version of Granger causality and cointegration techniques. They found that the economic growth causes energy consumption and leads to growth in petroleum consumption. However, electricity consumption leads to the economic growth. There is no cointegration relationship between economic growth and gas consumption. Meanwhile, results showed that energy consumption causes employment in Pakistan. There is a unidirectional causality running from economic growth to oil consumption. The government of Pakistan could implement policy on energy conservation so that oil could be used in more efficient way and gas could become a good substitute for oil. With energy conservation policy, petroleum consumption would not lead to adverse side-effects on economic growth in Pakistan.

Hatemi-J and Irandoust (2005) utilized the Granger causality methodology, which similar to the research by Cheng (1997), to examine the energy-income relationship for Sweden over the period 1965-2000. Apart from that, they applied the leveraged bootstrap stimulation technique to generate more reliable value for Granger causality tests. Results showed that energy consumption does not causes economic activity but it is caused by economic activity. Prices cause economic activity and energy consumption. Improvement in economic efficiency is resulting from increase in productivity that improves economic growth and affects energy consumption. According to them, economic efficiency is a determining factor of energy consumption and output behavior.

Chontanawat *et al.* (2006) used similar methodology of Granger causality to test for the causal relationship between energy and GDP for 30 OECD and 78 non-OECD countries. Data of 30 OECD countries was collected from 1960 to 2000 and data of 78 non-OECD countries was from 1971 to 2000. There were evidences of energy-GDP and GDP-energy causality for OECD and non-OECD countries. In the developed OECD countries, causality running from aggregate energy consumption to GDP and GDP to energy consumption is more widespread than in developing non-OECD countries. In the very poor countries, causality running from GDP to energy appears to be weak. This is because those poor nations have economies based on agricultural and are less dependent on energy use. Hence, the energy use in poor countries is not affected by the income. On the other hand, the degree of causality from energy to GDP is less in developing countries than in developed countries. This implied that energy conservation policies which help to combat global warning would have greater effect on the growth of developed countries than developing non-OECD countries. However, based on the results, causality was not found in China and India.

Ghouri (2006) reviewed the correlation between per capital GDP and per capital consumption of the Organization of Petroleum Exporting Countries (OPEC) countries, the Group 7 (G-7) countries (Japan, U.S., Italy, Germany, France, United Kingdom (U.K.), and Canada), and three Asian countries. He also estimated the ratios for total GDP and total energy consumption, and the GDP energy consumption elasticity. Results revealed that on a per capital basis, most of the OPEC countries exhibit negative and weak relationship for all forms of energy, including electricity. For G-7 and Asian countries, the relationship is strong and positive. However, there is a weak correlation for oil in G-7 countries. On the other hand, most OPEC countries have strong and positive correlation for the total GDP in relation to the total energy consumption.

Zachariadis (2006) had applied three methods to test for Granger causality between energy consumption and the economic variable in Germany and the U.S. The methods are VECM, Autoregressive Distribution Lag model (ARDL), and the Toda-Yamamoto (1995) test. For Germany, data was collected from 1971-2003 while data for U.S. was collected from 1949-2004. Results revealed that no causality found using all three methods between energy use and GDP in Germany. In U.S., there is neutrality between total energy and GDP. However, causality from energy to income is found in the service sector. In U.S. transportation sector, causality is running from income to energy. He found that energy consumption is affected by many variations and the impact is varying for each country because of different GDP structure and different mix of energy source available to each country.

According to Chima (2007), energy intensity or Intensity of Energy Use (IEU) is the amount of energy required to produce a unit of income (GDP). He had examined the energy-GDP relationship in the U.S. from 1949 to 2003 by using the IEU method. Results showed that energy consumption is sensitive to its prices, which will turn impacts to the GDP. It also showed that IEU has declined in the U.S. during the testing period. This implied that energy conservation policies are desirable in U.S. The nation can produce more income by implementing more efficient energy conservation policies and policies that promote improvements in technology for energy use plus the ability to substitute among various forms of energy inputs.

Cifter and Ozun (2007) had tested for the causality between energy consumption and economic growth using wavelet analysis. According to them, the wavelet analysis model can detect the multi-scale causality between electricity consumption and growth in emerging economies. They found that there is feedback relationship between GNP and energy consumption in the short run, while in the long run, GNP leads to energy consumption. By using wavelet correlation, it shown that GNP affects electricity consumption around 5-8 years later in the long run. Besides, they also found the magnitude of the wavelet correlation changes based on the time-scales for GNP and energy consumption. Therefore, GNP and energy consumption are fundamentally different in the long run.

To study the relationship between total energy consumption and GDP, and also industrial energy consumption and value-added in Beijing from 1978 to 2006, He *et al.* (2007a) had applied the stationary test, Granger causality test, cointegration test, and Error Correction Model analysis. The results indicated that there is a Granger causality relationship running from GDP to energy consumption and vice versa, mainly by the tertiary industry. This implied that Beijing is a metropolitan country. Results also showed the cointegration relationship between GDP and energy consumption in Beijing. They provide some opinion that Beijing should strengthen the secondary industry energy consumption management in order to save energy, optimize energy efficiency, and promote sustainable economic development under limited resources conditions.